DOCUMENT RESUME

ED 038 554 AA 000 539

AUTHOR Haney, Richard; And Others
TITLE Science Education Information Reports, Research Review Series - Science Paper 2, A Summary of Research in Science Education for the Years of 1965-67, Elementary School Level.
INSTITUTION Ohio State Univ., Columbus. ERIC Information Analysis Center for Science Education.
PUB DATE Dec 69
NOTE 32p.

EDRS PRICE EDRS Price MF-$0.25 HC-$1.70
DESCRIPTORS Curriculum, *Elementary School Science, Evaluation, Instruction, Learning, *Research Reviews (Publications), *Science Education, Teacher Education

ABSTRACT

This is one of several papers issued in cooperation with the National Association for Research in Science Teaching to analyze and synthesize research related to the teaching and learning of science completed over a two-year period. The research reviewed is grouped according to the standard categories used by the ERIC Science and Mathematics Education Information Analysis Center: Instructional procedures, teacher education, equipment and facilities, the curriculum, status of science programs, evaluation, and learning. Altogether 120 studies were reviewed. Investigations comparing the relative merits of two or more teaching methods were the most common studies on instructional procedures. Several studies on the characteristics of children and the relationship of these characteristics to science teaching were reviewed. Some of the other studies reviewed related to: various practices in the preparation of teachers, teachers' understandings of subject matter, survey of science programs, and patterns of intellectual growth, concept formation, and cognitive styles. (BR)

OE-X

ED 038 554

RESEARCH REVIEW SERIES - SCIENCE
PAPER 2
A SUMMARY OF RESEARCH IN SCIENCE EDUCATION FOR THE YEARS OF 1965-67, ELEMENTARY SCHOOL LEVE

SMAC/SCIENCE & MATHEMATICS EDUCATION INFORMATION ANALYSIS CENTER

. . . an information center to organize and disseminate information and materials on science and mathematics education to teachers, administrators, supervisors, researchers, and the public. A joint project of The Ohio State University and the Educational Resources Information Center of USOE.

SE000 539

SCIENCE EDUCATION INFORMATION

REPORTS

RESEARCH REVIEW SERIES - SCIENCE
PAPER 2
A SUMMARY OF RESEARCH IN SCIENCE EDUCATION
FOR THE YEARS OF 1965-67, ELEMENTARY SCHOOL LEVEL

by
Richard Haney, University of Wisconsin at Milwaukee
Donald Neuman, University of Wisconsin at Milwaukee
Dwight Clark, University of Wisconsin at Milwaukee
Cameron Smith, Unified School District, Racine, Wisconsin

THE OHIO STATE UNIVERSITY
ERIC Information Analysis Center
for Science Education
1460 West Lane Avenue
Columbus, Ohio 43221

December, 1969

RESEARCH REVIEWS - SCIENCE

Research Reviews are being issued to analyze and synthesize research related to the teaching and learning of science completed during a two-year period of time. These reviews are organized into three publications for each two-year cycle according to school levels--elementary school science, secondary school science, and college science.

The publications are developed in cooperation with the National Association for Research in Science Teaching. Appointed NARST committees work with staff of the ERIC Center for Science Education to evaluate, review, analyze, and report research results. It is hoped that these reviews will provide research information for development personnel, ideas for future research, and an indication of trends in research in science education.

Your comments and suggestions for this series are invited.

Robert W. Howe
and
Stanley L. Helgeson
Editors

SCIENCE EDUCATION INFORMATION REPORTS

The Science Education Information Reports are being developed to disseminate information concerning documents analyzed at the ERIC Center for Science Education. The Reports include five types of publications. General Bibliographies are being issued to announce most documents processed by the Center for Science Education. These bibliographies are categorized by topics and indicate the availability of the document and the major ideas included in the document. Special Bibliographies are being developed to announce availability of documents in selected interest areas. These bibliographies will list most significant documents that have been published in the interest area. Guides to Resource Literature for Science Teachers are bibliographies that identify references for the professional growth of teachers at all levels of science and mathematics teaching. This series will include six separate publications. Occasional Papers will be issued periodically to indicate implications of research for science and mathematics teaching. Research Reviews will be issued to analyze and synthesize research related to science and mathematics education over a period of several years.

The Science Education Information Reports will be announced in the SEIAC Newsletter as they become available.

INTRODUCTION

The rate at which studies of problems concerning the teaching of science in the elementary grades are reported is increasing rapidly. One hundred twenty studies were reported during the period of 1965 through 1967. As the volume of reports increases so does the problem of classifying them for the purposes of analysis. Many investigations were concerned with topics that could easily fit into several categories. In the development of this analysis several arbitrary decisions were made as to the classification of a report so that it would appear in a context with others of similar concern.

The studies reported here are concerned with instructional procedures, teacher education, equipment and facilities, the curriculum, status of science programs, evaluation, and learning. These categories are based on topics used in the General Bibliography Series published by the ERIC Information Analysis Center for Science Education, Columbus, Ohio and the nine fields for investigation defined by the National Association for Research in Science Teaching.[1]

---

[1]Research in the Teaching of Science, U.S. Office of Education Bulletin, OE-29000-61, 1965, No. 10.

STUDIES RELATED TO INSTRUCTIONAL PROCEDURES

Thirty-five studies were assigned to this category. These represented over 25% of all the studies analyzed. Most common were investigations of the relative merits of two or more teaching methods. Several studies were made of various methods for guiding the learning of pupils by means of lessons structured in a particular way or by programmed teaching materials.

Skinner (99) investigated the relationship between problem solving and expository teaching in televised geology lessons used with fifth grade pupils who followed up the televised lessons by engaging in either inquiry lessons or "typical discussions." Thirty-five classes with a total of 888 pupils participated in the study. Each school was assigned at random to one of the four treatment groups. The treatments consisted of the four combinations of two types of television presentations and two types of teacher directed follow-up discussions.

The televised problem solving lesson contained many unanswered questions and little direct explanation. The televised expository lessons presented the same subject matter largely by means of direct explanations. Pupils in the inquiry sessions asked "yes" or "no" questions of their teachers to gain information helpful in forming hypotheses. Pupils in the "typical discussion" sessions engaged in the normal pupil-teacher interaction that would ordinarily take place after showing a film.

The evidence indicated that pupils who viewed "unanswered questions" on television, regardless of the type of teacher follow-up, achieved significantly better than pupils who viewed "explanation" on television.

De Roche (29) investigated the relative effectiveness of "creative" exercises and "traditional" exercises in the teaching of a six week unit on space science in the sixth grade. Nine classes were taught with "brain storming" sessions and other lessons stressing creative thinking, while nine classes received no instruction in space science, but engaged in the testing program only. Among the findings were the following: (1) There was a significant relationship between intelligence and creative thinking and between intelligence and achievement. (2) High ability pupils who experienced the creative lessons were superior to other high ability pupils in terms of fluency, flexibility, originality and elaboration. (3) Average ability pupils who experienced the creative lessons were superior to other average ability pupils in terms of fluency, originality and elaboration. (4) Low ability pupils who experienced the creative lessons were superior to other low ability pupils in terms of elaboration. (5) There was no significant difference in achievement between the creative and traditional groups. (6) In the three groups there was a significant difference between males and females in space science achievement favoring the males.

Ziegler (119) investigated the relative effectiveness of the use of static and dynamic theoretical mechanical models in teaching elementary school children to use the particle idea of matter in explaining certain physical phenomena. The procedure consisted of personal interview, testing, teaching, and retesting a random sample of all the children in grades 2-6 in Janesville, Wisconsin.

The effects of instruction utilizing no treatment, the static model, and the dynamic model were measured directly; the pupils observed the eight demonstrations and then gave their explanations of the observed phenomena. When the data were analyzed it was found that (1) the scores earned by groups of pupils who tended to use models were significantly higher than those earned by the nonmodeler group when both received the same treatment, and (2) there were no significant differences in achievement between grade levels and no significant interaction effects.

Salstrom (91) analyzed the use of two types of sixth-grade guided discovery lessons for developing conceptual understanding: (1) a lesson in which pupils, working independently, choose from printed batteries of prepared hypothesis-questions, randomly arranged, or (2) a lesson in which all the hypothesis-questions are conceived and asked orally by the pupils and answered chiefly with "yes" or "no" by the teacher. The experimental lessons were presented as science games. Analyses indicated treatment one produced significantly greater conceptualization gains than did treatment two.

Gleason (44) compared the effects of pupil self instruction methods with the effects of teacher led classes in science with fifth grade pupils. Printed materials were used to instruct pupils working individually in the use of simple apparatus to solve problems. The approach was inductive and required pupils to generalize from observed phenomena. Four self-directed studies were tried with 128 pupils in six classes. The control group consisted of 132 pupils in seven classes. The study showed no advantage for self study over traditional methods as far as the learning of facts, general science knowledge, liking for science, and the ability to generalize were concerned. There were indications that pupils achieved in these areas as well by one method as by another.

Hedges and MacDougall (51) investigated the effects of programmed instruction in fourth grade science over a three year period. After the first year they found that children working independently with programmed materials achieved as well as children in traditionally taught classes. In a later phase of the study the relative effectiveness of three methods of instruction was investigated. Nineteen fourth grade classes were involved during the semester long study. One group studied science by means of programmed materials with each child doing the experiments. A second group used the programmed materials, but each child simply read about the experiment. A third group studied the same subject matter written in a traditional textbook form with brief assignments by the teacher and teacher demonstration of the experiment. Among their findings were the following: (1) Children who are allowed to actively participate in performing laboratory experiments have a greater proficiency than others in the solution of sample problems. (2) There were no significant differences between these methods in their effect on interest, science achievement, or retention of subject matter by the pupils. (3) The two groups having direct contact with experimentation reported the highest degree of liking for science. (4) During the semester of instruction the textbook group with students doing the experiments shifted to a slightly less positive liking for science while the programmed group that only read about the experiments shifted to distinct dislike.

An additional study compared three methods of programmed instruction. These were (1) constructed response compared to multiple choice, (2) all answers compared to partial feedback, and (3) branching compared to linear programming. All students were allowed to perform their own experiments since the importance of this factor to student interest in science already had been demonstrated. No superiority was found in mean achievement interest and attitude measures among the structure, method, and frequency variables. The experimenters were not successful in identifying "the incentive in programmed instruction that supposedly makes response-confirmation an act of reinforcement." The investigators found no significant differences between the use of multiple choice answers and constructed responses. Further investigation was suggested to determine what topics and learning tasks are more appropriate for each method of response. Finally, no significant difference was found between linear structuring and branching; the investigators tend to attribute this as much to the content or writing as to the method of presentation.

The effectiveness of two methods, recitation-demonstration and project-research, were compared by Drenchko (31) for teaching elementary school science. Comparisons were made regarding (1) the knowledge of the subject matter acquired by the student, (2) the ability of the student to understand and apply concepts and generalizations of the subject, and (3) the work study skills developed by the student. The sample was comprised of fourth grade students in classes selected randomly from four schools in the Hillsborough Township Public Schools. One class in each school was taught by recitation-demonstration methods, one by project-research methods without individual projects, and one by project-research methods with individual projects. The recitation-demonstration group was taught by regular assignments, question and answer recitations, and demonstrations performed predominantly by students. The project-research group covered the same topics, but they were given a general problem to solve. The latter group was also given inquiry training such as the "yes-no" response technique. The groups were pretested and posttested using investigator constructed unit achievement tests and the STEP science tests. It was concluded that (1) in terms of growth in subject matter knowledge the project-research method without individual projects appears to be superior to the project-research method with projects and also superior to the recitation-demonstration method; (2) most students of this age group are not prepared to handle individual projects of the type used in this study; and (3) there were no significant differences between methods and students' growth in problem solving ability and work study skills. More students in the project-research groups had greater interest in science at the end of the study.

Other studies of instructional methods were conducted by Baum (3), Bennett (4), Bennett and Clodfelter (5), Breddeman (10), Brudzynski (13), Coulter (23), Crabtree (24), Decker (27), Fryback (39), Gehrman (40), Gerne (41), Glaser (42), Glaser and Others (43), Haugerud (50), Jarvis (57), Lansdown and Dietz (65), O'Toole (78), Quilling and Others (85), Raun (87), Reese (88), Sands and Hicklin (92), Sands and Others (93), Smith (100), Smith and Cooper (101), Tating (107), Taylor (108), Voelker (114), and Zeitler (120).

STUDIES RELATED TO TEACHER EDUCATION

Twenty-six studies were concerned with the characteristics and preparation of teachers of elementary school science. Cheney (21), Hines (55), Leake (66), and Soy (104) investigated attitudes of teachers toward science instruction. In his study of the committment of prospective teachers to science teaching Cheney (21) found that students completing a laboratory-oriented pre-service science methods course (an elective) had a tendency to "deplore their weakness in science." However, this was not matched by efforts to remove deficiencies. Students lacked interest in becoming science teaching specialists. They resisted instructions to emphasize non-expository teaching and pupil involvement, and instead tended to stress the giving of explanations even when this involved the teaching of misconceptions. These prospective teachers expected science to be a favorite subject of many children.

Teachers' understanding of the subject matter of science was the subject investigated by Beringer (6), Caruthers (19), Eaton (33), Eccles (34), Hardin (48), Lane (64), Raina (86), and Uselton (112). Their general findings were that for the most part elementary teachers are inadequately prepared to teach science. Lane (64) devised a paper and pencil instrument to measure the competence of teachers in the processes of science as the term is used in the AAAS program, <u>Science - A Process Approach</u>. He administered this test to one hundred teachers representing two counties in Florida and on the basis of the results classified 7% of the teachers as highly competent, 80% as having average competence and 13% as of low competence.

Raina (86) tested the general science knowledge held by a sample of 100 student teachers in two teacher training institutions in India. He found that they did not compare favorably with VIII Class secondary school children who comprised the norms for the instrument.

Eaton (33) studied the development of science concentrations for prospective teachers at the University of Texas and among his findings was the fact that 67% of the student teachers he examined reported that the science topic they would like to teach was one in which they had received no related instruction at the university level. He found that prospective teachers lacked insight into the relationship between the science studied at the university and teaching in the elementary school classroom. He concluded, "If teachers are to perceive the relationship between content and instruction it would appear that effort will have to be made to assist the undergraduate in building this connection."

Various practices in the preparation of teachers were described and evaluated by Banks (2), Hiack (54), Kellogg (60), Moorehead (74), Thomas (110), Weichinger (115), and Weigand (116). Hiack (54) developed a series of fifteen laboratory experiments for use in a one semester physical science course for prospective teachers. The experiments were designed to emphasize the use of the processes of science as interpreted by the AAAS in Science - A Process Approach.

The effectiveness of in-service programs for teachers was studied by several persons. Wilson (117) investigated the benefits of a program which provided instruction in the "inquiry-discovery approach" as employed in the Science Curriculum Improvement Study. He found that teachers could be taught to increase in their teaching the number of "essential science experiments" and the number of questions that required analytical thinking.

Hoffart (56) described the role that some high school teachers can play in disseminating "new" elementary science curriculums after having been exposed to them in in-service programs. He also reported a study producing inconclusive results in which sixteen high school physics students taught ESS units in the elementary grades over a period of three weeks.

The effect of videotaped elementary school science classroom demonstrations on science teaching performance of pre-service teachers was studied by Kriebs (63). On the basis of her investigation she recommends increased use of videotaped classroom episodes showing children using scientific methods for teacher training.

Other evaluations of in-service programs were made by Brittain (11), Coffey (22), McBride (72), and Rowe (89).

STUDIES RELATED TO EQUIPMENT AND MATERIALS

A number of useful items were produced or evaluated. Croasdale (25) developed a sourcebook for the elementary science program of the Science Manpower Project at Columbia University entitled, Machine, Materials, and Energy. Brown (12) produced a dictionary for the science vocabulary used in the upper elementary grades. Novak (77) developed an audiotape program of instruction for elementary science.

Reading materials were considered by several persons. Shadoin (98) developed a procedure by which selected technical data can be adapted for use as science enrichment in the elementary school. In a like manner Bradley and Earp (9) reported how an article from Scientific American could be translated into the language of elementary school children. Newport (76) and Ottley (79) both compared evaluated text book series in terms of criteria which they developed.

The problems involved in planning science facilities were studied by Heldman (52). He surveyed the existing facilities in twenty schools in the New York metropolitan region and then developed recommendations concerning the need for a full time science room in all schools, improved storage facilities, outdoor facilities, and more adequate financing of science programs.

STUDIES RELATED TO THE CURRICULUM

The problems of selecting and organizing the subject matter to be taught in science programs were considered by fourteen persons. Floyd (38) tested fifth, sixth and seventh grade pupils in 21 schools in central Illinois and found that "pupils knew a considerable amount of content of seventh grade science textbooks prior to instruction."

Boener (8) evaluated the grade placement of science concepts in the reorganized curriculum of the early grades of the Minneapolis public schools. On the basis of her findings of appropriateness she concluded that the teacher committee was an acceptable method of curri lum development.

A list of aerospace principles that are desirable for inclusion in fifth or sixth grade science programs was developed by Johnson (58) with the help of scientists at the National Center for Atmosphere Research and the National Bureau of Standards, science educators, and elementary science specialists. He found the development of a plan of study which would include all phases of aerospace phenomena to be difficult because the relevant principles were drawn from several fields of science. He found current science textbooks to be poorly suited as a basis for instruction in aerospace phenomena and indicated the need for new resource materials.

Existing science handbooks and curriculum guides were surveyed by Vinci (113) and Trout (111). They found inadequacies including lack of correlation between objectives and subject matter, insufficient laboratory activities to teach the concepts that were included, and a need for improved methods of orienting teachers to the use of handbooks. Glaser (42) studied the problem of adapting the elementary school curriculum to individual performance.

Four studies were concerned with the relationship of industrial arts to science. Champion (20) found that industrial arts (1) can be implemented in the elementary school curriculum through integration with other subjects, (2) provides an effective means for demonstrating the value of other subjects, and (3) stimulates interest in learning. Similar findings were made by Pershern (82) and Griffin (45). Ljostad (68) developed a guide for teachers suggesting industrial arts activities to enrich the teaching of elementary school science.

Two theoretical and analytical studies of curricular problems which could very well have an impact on future developments in elementary science programs were conducted by Scott (95) and Price (84). Curriculum planning committees would do well to examine these two studies. Scott (95) analyzed the cognitive behaviors required by an elementary science curriculum plan, Science - A Process Approach and established a model for making cognitive analyses of other curriculum proposals.

> For each activity in this curriculum plan a list was made of cognitive behaviors required of students. Cognitive behaviors used were those described in Taxonomy of Educational Objectives.

Each activity was represented in the final analysis by its most complex cognitive requirement or "top coding." Activities which could not be given unequivocal codings, because of the variables of teacher technique and student background, were represented by their highest possible codings. The method of analysis was rational or introspective rather than experimental.

Science - A Process Approach was found to be systematically progressive. Earlier grade books of this program tend to require fewer of the more complex cognitive behaviors than later books. Later grade books tend to have fewer activities with "top codings" in lower cognitive categories. When one examines the several "processes of science" around which the program is organized the same progressive tendency is found. Five of six primary grade processes show the tendency. When primary grade processes as a block are compared with intermediate grade processes as a block the tendency is found.

Activities requiring cognitive behaviors in the Comprehension (2.00) and Application (3.00) categories were located in all six books of the curriculum. Behaviors in Analysis (4.00) categories first appear in the third book and are used thereafter. Synthesis (5.00) behaviors were found only in books five and six. No instances of Evaluation (6.00) behaviors were found.

The cognitive behavior most frequently used as highest required one in activities is Interpretation (2.20), a Comprehension behavior. Other cognitive behaviors required, in order of occurrence, are Translation (2.10), Extrapolation (2.30), Application (3.00), Analysis of Relationships (4.20), Analysis of Elements (4.10), Analysis of Organizational Principles (4.30), and Production of a Plan or Proposed Set of Operations (5.20). No instances were found of the other two Synthesis behaviors as "top codings."

Differences among cognitive categories were shown with statements from the taxonomy and with examples from curriculum activities. An attempt was made to identify those behavioral requirements that were characteristic of the several cognitive categories. For example, it was found that activities requiring behavior in the Analysis (4.00) range characteristically required two distinct Application (3.00) behaviors. The distinction between Analysis (4.00) and Synthesis (5.00) behaviors was found to depend upon the number of available routes to a problem's solution: one route to the correct answer is indicative of Analysis: two or more possible routes to correct answers is indicative of Synthesis.

For four of the eight cognitive categories located in Science - A Process Approach it was possible to group all instances of the category into a few basic types. For example, it was found that all instances of Interpretation (2.20) behavior could be grouped into these seven types: understanding concepts, understanding rules and procedures, getting the big picture, making subsets from one set, making assessments, drawing conclusions, and comparing and ordering. (95, pp. 2-3)

Price (84) developed a conceptual framework for the selection and organization of the subject matter of science for the elementary school science curriculum. The procedure involved (1) assembling ideas concerning the structure of knowledge about natural phenomena studied by scientists, (2) assembling ideas about the growth of substantive concepts in elementary age children, and (3) organizing these facts to form a conceptual framework from which sound decisions can be made for selecting and organizing the subject matter of science. Two bodies of literature were reviewed: (1) descriptions of the phenomena of nature and (2) descriptions of intellectual development from the point of view of cognitive theorists.

A set of criteria was developed, based on the structure of science and the characteristics of intellectual growth, to aid the curriculum planner in selecting and organizing the subject matter. One group of criteria pertains to the selection of learning experiences to provide the student with the full scope of the domain of science. A second group of criteria pertains to the organization of learning experiences to provide for the optimal matching of experience with intellectual readiness.

The conceptual framework is designed to suggest: (1) the scope of natural phenomena to be studied, (2) a logical and psychological ordering of the constructional realm of science, (3) the sequence and general grade level allocation of learning experiences based on the phenomenal and constructional aspects of science and characteristics of intellectual growth, and (4) a plan for integrating ideas about nature into a unified structure of knowledge.

The objective of scientific literacy as related to the media of mass communication was studied by Koelsche (62). He examined the contents of 2999 science-oriented news items clipped from a sample of 22 newspapers and nine widely-read magazines over a six month period. Among his findings are the following. (1) The median level of reading comprehension needed in order to interpret and understand material in the science articles was on the eleventh grade level with extremes of grades four and sixteen. (2) Lists of 693 words and 175 basic science principles were identified which one would have to understand in order to read the articles with meaning. Scientific literacy was defined by Koelsche as "---a level of science education achieved by people when their backgrounds in science are such that they can understand, interpret, and interrelate scientific phenomena with facility, and form relevant and independent conclusions from information acquired through the media of mass communication."

STUDIES RELATED TO THE STATUS OF SCIENCE PROGRAMS

Seven surveys of practices were reported. Of these the nation-wide study conducted by Blackwood (7) of the U. S. Office of Education was the most extensive. He distributed a questionnaire to a sample of schools representing all the elementary schools in the United States to obtain information concerning various facets of science teaching practice. Among his findings are the following: (1) Concerning objectives, 99% of the schools considered development of curiousity to be an important objective while at the other extreme the development of scientists, preparation for high school, and development of leisure time science activities were considered to be of little or no importance. (2) Only a few schools reported that no science at all was taught during the year. The larger the school enrollment, the larger the percent of schools that taught science more than half a year. (3) In grades where science was taught by the regular classroom teacher, science taught as a separate subject and science taught as incidental science emerged as the patterns that were most common in the upper grades, with the percent of schools teaching science integrated with other subjects being the highest in the earliest grades and lowest in the upper grades. (4) Almost without exception, the median number of minutes of science per week increased by grade up to grade seven. A small but significant percent of all schools taught science less than 20 minutes a week at almost every grade level. A substantial number of schools taught science more than 200 minutes per week in the fifth, sixth, seventh, and eighth grades. (5) A large proportion of schools did not offer departmentalized science instruction at any grade level, though the larger the schools, the more prevalent was departmentalization at some grade level. The larger the administrative unit enrollment the greater the proportion of schools that were departmentalized. Of all schools, about 15% were departmentalized and 85% were not. (6) Science was taught most frequently, by far, by the classroom teacher with no help from a science specialist. Approximately 30% of the schools having enrollments of 800 and over reported that special science teachers attached to the central office staff were available for helping teachers. Television was reported often as the primary source of science teaching. (7) Of all schools, 41.8% had consultant help in science. (8) Science textbooks played a key role in determining what content was studied in the elementary school. They were used more than any other aid in all grades except kindergarten. (9) About 18% of all schools did not adopt a science textbook for grades one to three. This figure dropped to 5% for grades four to eight. Approximately one-fourth of all schools adopted two or more science textbooks at every grade level. The largest school systems seemed less dependent on single science textbooks than the smaller ones. (10) Eight percent of all schools indicated that the availability of equipment and supplies was very plentiful, 46% generally adequate, and 46% responded that equipment and supplies were far from adequate or completely lacking. Nearly half of the schools with enrollment of 49 and under spent from zero to 20 cents annually per pupil for equipment and supplies and one-fifth spent over $1.50 per pupil. About 43% of the schools having enrollment of 800 and over spent from zero to 20 cents per pupil and 9.2% spent $1.51 and over. (11) The most commonly reported barrier to effective science teaching was lack of adequate consultant service. (12) Nearly two-thirds of all schools reported that they participated in curriculum development and revision at the school systems level. (13) Over 65% of all schools had college sponsored elementary science course available to teachers. Nearly 40% of all schools used television and radio programs at local school level and 35% at the school system level for in-service education in science.

Based on these findings eight recommendations were offered by Blackwood to improve science instruction in elementary schools.

Other surveys of practices in elementary school science instruction were conducted by Dillon (30), Kenyon (61), Senter (97), Snoble (103), Swan (106), and the Wisconsin State Department of Public Instruction (118).

STUDIES RELATED TO EVALUATION

Four studies were concerned with the development of measuring instruments. Butler (15) developed a test for measuring selected life science concepts of elementary school children. The content of the test was based on six characteristics of living things: (1) structure, (2) metabolism, (3) growth, (4) reproduction, (5) responsiveness, and (6) adaptation. The test items each consisted of a plate made up of six pictures. Correct pupil responses to each of the pictures were interpreted as evidence that the concept has been attained.

Jones (59) developed a test of scientific inquiry, using the tab format, and analyzed its relationship to selected student behaviors and abilities.

Finkelstein (37) developed a "reading free" test procedure for the evaluation of knowledge and understandings in elementary school science in an attempt to evaluate the achievement of poor readers. The test was presented by means of color slides accompanied by a taped script which asked the questions and provided the multiple choice responses. To determine the effectiveness of this test Finkelstein constructed a parallel test concerning the same content, but presented by means of printed test booklets. Both tests were administered to a group of 300 children consisting of above average, average and below average readers. He found that students in all three reading categories scored significantly higher on the reading free test than on the traditional form of the test with the greatest differences obtained by the below average readers. Boys obtained significantly higher scores on the reading free test than did girls, but there was no significant difference between boys and girls on the traditional form of the test. Finkelstein concluded that educators must move away from traditional evaluation procedures which rely heavily upon reading facility. He suggested that the use of a multisensory testing procedure could establish a new base for understanding and assessing student achievement.

Lowery (69) developed an attitude measuring instrument for science education which consisted of three individualized projective tests: A word association test, an apperception test and a sentence completion test. In the appreception test the subject must supply a meaning and interpretation to a neutral situation in the form of a drawing. The test was administered to a sample of children and scored by a jury of experts in science education. Coefficients of reliability and validity were determined. Lowery concluded that this projective technique was superior to the usual questionnaires for determining the attitudes of children concerning science.

STUDIES RELATED TO LEARNING AND PUPIL CHARACTERISTICS

Twenty-eight studies concerning either patterns of intellectual growth, concept formation, cognitive styles or other characteristics of pupils which are of significance to science education were reported. Englemann and Gallagher (36) studied the Piagetian concept of conservation and its relation to five and six year old children's concept of the property of liquids. By means of an investigator-constructed inventory and the Peabody Picture Vocabulary Test, the conservation and mental abilities of the children were determined. Non-conservers were separated into two groups and matched on the basis of mental ability. The experimental group was given a series of five training sessions stressing conceptual independence and compensation by means of lessons emphasizing observation rather than direct experience. A significant improvement on the conservation inventory posttest was reported only for the experimental group. The investigators concluded that properties of liquids related to conservation ability can be taught through instruction.

Carlson (18) studied the effects of several styles of instruction on conservation of substance. More specifically, he was concerned with differences in conservation ability in children receiving instruction stressing verbal mediators and direct action versus observation of a demonstration. In carrying out the study four experimental conditions were established: (1) High verbal-demonstration; (2) high verbal-direct activity; (3) minimal verbal-demonstration; and (4) minimum verbal-direct activity. All children were given two, twenty-minute training sessions. A control group had no training. Following the training sessions, all children were given a fifteen item criterion measure based on material similar to that used in the training sessions. It was found that all experimental groups out performed the control group on the criterion measure. In addition it was found that children receiving highly verbal instruction scored significantly higher than children receiving minimal verbal instruction. Carlson concluded that (1) providing children with verbal rules and verbal mediators is an effective method of instruction and (2) direct experience is not more efficacious than demonstration techniques.

Gunnels (46) set out to discover whether inferences that students in grades four through nine draw from science tests corresponded to the three-stage development of reasoning postulated by Piaget. He further compared instances of the three levels of thinking by grades. Children were classified as successful problem solvers or unsuccessful problem solvers by means of a pretest. These children were then presented individually with seven science problem situations and interviewed to determine the various problem solving procedures employed by children of different grade levels and ostensibly different positions on Piaget's developmental hierarchy. It was found that the older a student is, the higher his mental age, and the higher the actual grade level of a pupil, the more likely is he to use the formal level of operational thought in solving science problems.

Phillips (83) studied the acquisition of the concept of displacement volume by means of conservation tasks and found a predictable sequential order of attainment as well as significant differences in task attainment between grade levels. No significant differences resulted when material objects were presented directly or when graphic representations of those objects were presented to the experimental subjects.

Dyrli (32) investigated the effect of systematic and specific references to methodological and logical elements in the behavior of the individual on the development of combinatorial operational skills. It was found that the combinatorial skills of students who were theoretically in a transition period between concrete and formal operations could be improved significantly. On the other hand, instruction in combinatorial strategy did not appear to accelerate the skills beyond that which was observed to occur without treatment.

Allen (1) used the Piaget-Kofsky 11 item classification hierarchy to compare the classification ability of students exposed to the Science Curriculum Improvement Study and students in a control group who lacked such exposure. No significant difference in performance, either qualitative or quantitative was detected.

Thier (109) evaluated the effect of the first grade science unit Material Objects as developed by the Science Curriculum Improvement Study on a group of first grade children. He compared responses of children who studied this unit to those children who did not study it. He asked questions related to the stated objectives of the unit and additional questions attempting to elicit the children's general understanding of the concept: matter. In general, children who studied the unit were superior in their ability to describe objects by their properties; they were able to report a greater number of similarities and differences between objects; and they were better able to observe an experiment and use their observations to describe what happened than were children in the control group. There were no differences between the two groups of children in their ability to describe an experiment that could provide theoretical information about observed phenomena.

Stauss (105) investigated the relationship between concept attainment and level of maturity. The main focus of the study was to identify the concepts included in the conceptual scheme, the biological cell, and determine the grade level at which each concept was most appropriate (grades two through six). Three levels of understanding, knowledge, comprehension, and application, were used to design an achievement test for determining the grade placement of the eleven biological concepts selected. In a similar study, Haddad (47) identified concepts within the conceptual scheme of relativity and attempted to determine the relationship between levels of understanding of these concepts among pupils in grades four through eight. Using a self-prepared evaluative instrument designed to test the child's achievement on 29 relativity concepts, the investigator identified a hierarchy of concepts and determined achievement in them to be a function of the maturity of the child. No hierarchy was indicated by levels of achievement of children in different grades between the three basic units: classical, general, and special relativity.

Helgeson (53) studied the relationship between the concepts of force attained by children and their level of maturity as indicated by grade levels. Concepts that make up the conceptual scheme, force, were identified and children in grades two through six were given training sessions, then tested to determine an appropriate hierarchy for presenting the eight concepts. It was found that maturity as indicated by grade level was a factor in determining a child's success for each of the eight concepts.

Carey (17) investigated the relationship between levels of maturity and levels of understanding of the particle nature of matter. As in each of the three previous studies, concepts within the conceptual scheme were determined and a hierarchy for presentation of concepts based on children's level of achievement of each concept was developed.

Brusini (14) studied the ability of children at different grade levels to develop and form an abstract science concept that requires the recognition of a continuum. Children from grades three through eight were tested for their ability to form the geologic concept known as the cycle of stream erosion. It was found that the ability to form a science concept which requires the recognition of a continuum is highly associated with the amount of direction given a child and to a lesser degree with both chronological and mental age.

Dennis (28) experimented with the grade placement of concepts using kinetic molecular theory as the subject matter. He presented a series of science lessons on aspects of kinetic molecular theory of matter to approximately 200 children in grades two through six. He found that these concepts could not be taught effectively to children having less than third grade mental ability.

Harris and Lee (49) conducted a pilot study relating to science concepts and mental age. Menefee (73) and Lown (71) studied factors related to the use of scientific instruments by elementary school pupils. Lipson (67) investigated the concepts of light understood by elementary school pupils and college freshmen.

Three studies related to cognitive styles were reported during the period covered in this report. Cunningham (26) studied the relative predisposition of children to be inflexible, especially when confronted with open-ended situations. Einstellung, or the "susceptibility to set," appeared to play an important role in the success or failure of inquiry laboratory activities. An inverse relationship was found between age and susceptibility to set.

Schulz (94) studied the effect of advance organizers, as defined by Ausubel, on the learning of meaningful material. In particular, the principle of conservation of energy was used as an advanced organizer in a science unit developed for sixth grade children. Although evidence was inconclusive, it appeared that advance organizers facilitated learning among pupils who lacked the processing skills necessary to reorganize information independently.

Scott (96) investigated the relationship between a strategy of inquiry and styles of categorization by working with three hundred children in grades four, five and six. They were taught a series of 15 science concepts, five at each grade level. Half of the children were taught by means of the Detroit Inquiry process and the other half were taught by conventional methods. At the end of the year all of the children were given a "Styles of Categorization Task." It was found that in grade four the inquiry groups were less inclined to categorize pictures of familiar objects on the basis of use, or function, than were children who were taught conventionally. In grade five, girls were more able than boys to shift stimuli and methods of categorization. Within grade six, the conventionally taught children provided more functional labels, whereas the inquiry groups classified familiar items on the basis of manifest details and inferred attributes more so than did the conventionally taught pupils. It was found also that the inquiry pupils were more flexible in their classification behavior than were those children taught conventionally.

Six studies were reviewed that were concerned with the development of a particular intellectual skill. Edwards (35) constructed lessons in science designed to facilitate instruction of the predetermined skills of observation, classification, data treatment, and measurement. Upon completion of the series of lessons a random sampling of children were tested to determine whether or not they had made significant gains towards meeting the objectives of the study. It was found that the lessons were effective in helping kindergarten children develop the selected intellectual skills considered part of the scientific endeavor.

Butts and Jones (16) identified factors related to changes in children's problem solving behaviors. The investigators then provided inquiry training for a group of sixth-grade children. An inventory of science processes related to problem solving was prepared and administered to the training group and a control group. A significant relationship between inquiry training and problem solving ability was observed. No relationship between inquiry training and concept transfer or recall of actual information was observed.

Nasca (75) studied the effect of various presentations of laboratory exercises using programmed materials on specific intellectual factors of scientific problem solving behavior. His major conclusion was that active participation in experiments supporting scientific principles was superior for development of at least one phase of non-verbal problem solving ability. No such superiority of method was found when verbal abilities were measured. Nasca suggests that this project "demonstrated the feasibility of developing unifactor test instruments for the purpose of detecting precisely how limited variables in educational experiences effect student behavior."

A number of studies on the characteristics of children and the relationship of these characteristics to science teaching appears in the current literature. Attitudes and interests of children in various grades and the effects of socio-economic level on success in science make up the kinds of studies reported. Lowery (70) studied changes in attitudes of children exposed to new curriculum materials and relationships between attitude changes and socio-economic status. It was found that higher "area" children held a more positive attitude toward science. In addition, exposure to the materials of a new science curriculum project caused a positive change in attitude toward science. Smith (102) investigated differences in the capacities of children from varying socio-economic levels to comprehend selected physical science concepts. It was found that pupils in low socio-economic groups scored significantly lower than children in high socio-economic groups. Rowland (90) compared the science achievement of sixth grade children of high socio-economic status. He found that given equal intelligence and equal science background experiences higher socio-economic status pupils exhibit greater science achievement than do lower socio-economic status pupils.

Raun (87) investigated the problem of changes in cognitive and affective behavior of children given experience with the strategies of inquiry. No significant relationship between strategies of inquiry and attitude toward science was observed in this study. Two other studies dealing with children's attitudes and interests toward elementary science were reported by Perrodin (80, 81).

COMMENTARY

While the quantity of studies has increased greatly in recent years the improvement in the quality and general usefulness of the research has not kept pace. Several factors continue to make it difficult for reviewers to draw meaningful generalizations from large groups of studies. The most important of these is the lack of a precise language of science education. When different investigators use such terms as concept, attitude, process, inquiry, discovery, critical thinking, problem solving, etc. it is almost always the case that they employ them with different meanings. Until there is a commonly accepted language it will remain difficult for science educators to establish general principles for science instruction.

Closely related to this lack of a common language is the global nature of the variables which have been the concern of many investigators. Too many continue to study such problems as the "new" method versus the "traditional" method, and demonstrations versus laboratory activities. Experimental studies often involve treatments carried on over relatively brief periods on experimental and control groups which are not representative of generally familiar population.

Finally, the value of data derived from investigator-produced measuring instruments are often of questionable value. In many cases these instruments are hastily constructed and evaluated because they are to be used to measure some variable which is under investigation. Actually, the identification of an important variable and the development of an instrument to measure it are of such value that this alone can constitute a doctoral study. Too many persons are trying to do too many things in one investigation with the result that none of them are done well.

These comments are not aimed particularly at the scholars whose works have been reviewed in this article. The fact that these difficulties continue to plague us is evidence that science education is not yet a very mature science. It is dependent for its concepts and theories upon other fields such as psychology, philosophy, and sociology as well as the natural sciences. Each of these embody differing schools of thought and exist in differing stages of development.

Perhaps one step towards ameiorating this state of affairs would be the conducting of large scale investigations by coordinated teams of researchers over longer periods of time than are studied at present. But these are exactly the type of studies that would be impractical for doctoral candidates unless there were coordination of the efforts of numerous university staffs. Certainly there seems to be an unfulfilled role here for the National Association for Research in Science Teaching.

BIBLIOGRAPHY

Documents with ED information are available from EDRS, National Cash Register Company, Bethesda, Maryland 20014.

1. Allen, Leslie R. "An Examination of the Classificatory Ability of Children Who Have Been Exposed to One of the 'New' Elementary Science Programs." Unpublished doctoral dissertation, University of California, Berkeley. 1967.
   ED 026 245 MF $0.75 HC $7.05 139 p.

2. Banks, William Jr. "Practices in the Preparation of Elementary Teachers For the Teaching of Science." Unpublished doctoral dissertation, The Ohio State University, Columbus. 1965.

3. Baum, Ernest A. "Report of the Individualization of the Teaching of Selected Science Skills and Knowledges in an Elementary School Classroom With Materials Prepared by the Teacher." Unpublished doctoral dissertation, Columbia University, New York. 1965.

4. Bennett, Lloyd M. "A Study of the Comparison of Two Instructional Methods, the Experimental-Field Method and the Traditional Classroom Method, Involving Science Content in Ecology For the Seventh Grade." Science Education 49: 453-468; December 1965.

5. Bennett, Lloyd M., and Cherie Clodfelter. "A Study of the Integration of an Earth Science Unit Within the Reading Program of a Second Grade by Utilizing the Word Analysis Approach." School Science and Mathematics 66: 729-736; November 1966.

6. Beringer, Marjorie L. "A Critical Analysis of Teacher Understanding of Scientific Fact." Unpublished doctoral dissertation, University of Southern California, Los Angeles. 1965.

7. Blackwood, Paul E. "Science Teaching in the Elementary School - A Survey of Practices." Journal of Research in Science Teaching 3: 177-197; September 1965.

8. Boener, Charlotte M. "An Evaluation of the Grade Placement of Science Concepts in the Early Elementary Grades of the Minneapolis Public Schools." Unpublished doctoral dissertation, The University of Iowa, Iowa City. 1965.

9. Bradley, R. C., and N. Wesley Earp. "A Method of Producing Up-To-Date Science Material for Elementary Children." Journal of Research in Science Teaching 4: 102-105; June 1966.

10. Bredderman, Theodore A. "The Relative Effectiveness of Reinforcement and Conflict Instruction in Developing the Ability to Separate Variables in Fifth and Sixth Grade Children." Unpublished doctoral dissertation, Cornell University, Ithaca, New York. 1967.
    ED 021 706 MF $1.00 HC $10.75 213 p.

11. Brittain, Clay V., and Edithgene Sparks. "Changes in Teaching Difficulties Reported by Teachers Completing an Inservice Course in Science." Science Education 49: 152-156; March 1965.

12. Brown, Richard A. "A Determination of the Science Vocabulary Used in the Upper Elementary Grades and the Production of a Dictionary For That Vocabulary." Unpublished doctoral dissertation, Colorado State College, Greeley. 1965.

13. Brudzynski, Alfred J. "A Comparative Study of Two Methods for Teaching Electricity and Magnetism With Fifth and Sixth Grade Children." Unpublished doctoral dissertation, Boston University School of Education. 1966.
ED 021 708 MF $1.00 HC $11.60 230 p.

14. Brusini, Joseph A. "An Experimental Study of the Development of Science Continua Concepts in Upper Elementary and Junior High School Children." Unpublished doctoral dissertation, Northwestern University, Evanston, Illinois. 1966.
ED 026 246 MF $0.50 HC $6.35 125 p.

15. Butler, Delbert F. "A Test For Measuring Selected Life Science Concepts of Elementary School Children." Unpublished doctoral dissertation, George Peabody College for Teachers, Nashville, Tennessee. 1965.
ED 013 206 MF $0.75 HC $6.60 130 p.

16. Butts, David P., and Howard L. Jones. "Inquiry Training and Problem Solving in Elementary School Children." Journal of Research in Science Teaching 4: 21-27; March 1966.
ED 010 995 MF $0.25 HC $0.70 12 p.

17. Carey, Russell L. "Relationship Between Levels of Maturity and Levels of Understanding of Selected Concepts of the Particle Nature of Matter." Unpublished doctoral dissertation, The University of Wisconsin, Madison. 1967.

18. Carlson, Jerry S. "Effects of Instruction on the Concepts of Conservation of Substance." Science Education 51: 138-145; March 1967.

19. Caruthers, Bertram, Sr. "Teacher Preparation and Experience Related to Achievement of Fifth Grade Pupils in Science." Unpublished doctoral dissertation, The University of Nebraska Teachers College, Lincoln. 1967.

20. Champion, George. "The Interrelationship of Industrial Arts With Science in the Elementary School." Unpublished doctoral dissertation, University of Maryland, College Park. 1965.

21. Cheney, Bruce D. "Commitment to Science Teaching Among Prospective Elementary School Teachers: An Exploratory Study." Unpublished doctoral dissertation, The University of Illinois, Urbana. 1966.

22. Coffey, Warren C. "Change in Teachers' Verbal Classroom Behavior Resulting From an In-Service Program in Science Education." Unpublished doctoral dissertation, University of California, Berkeley. 1967.
ED 027 178 MF $0.75 HC $8.05 159 p.

23. Coulter, John C. "The Effectiveness of Inductive Laboratory, Inductive Demonstration, and Deductive Laboratory Instruction in Biology." Unpublished doctoral dissertation, The University of Minnesota, Minneapolis. 1965.

24. Crabtree, J. F. "A Study of the Relationships Between 'Score', 'Time', 'I. Q.', and 'Reading Level' For Fourth Grade Students Using Programed Science Material." Science Education 51: 298-304; April 1967.

25. Croasdale, William. "Machines, Materials, and Energy: A Sourcebook For the Modern Elementary School Science Program of the Science Manpower Project." Unpublished doctoral dissertation, Columbia University, New York. 1966.
ED 027 186 MF $1.25 HC $16.30 324 p.

26. Cunningham, John D. "Einstellung Rigidity in Children." Journal of Experimental Child Psychology 2: 237-247; September 1965.

27. Decker, Martin G. "The Differential Effects Upon the Learning of Natural Sciences by Fifth Graders of Two Modes of Teaching Over Television and in the Classroom." Unpublished doctoral dissertation, Boston University School of Education. 1965.
ED 002 027 MF $0.75 HC $8.50 168 p.

28. Dennis, David M. "The Introduction of Concepts in Kinetic Molecular Theory to Children." Journal of Research in Science Teaching 4: 106-111; June 1966.

29. DeRoche, Edward F. "A Study of the Effectiveness of Selected Creative Exercises on Creative Thinking in Elementary Science." Unpublished doctoral dissertation, The University of Connecticut, Storrs. 1966.

30. Dillon, Jessee D., Jr. "An Analysis of Science Teaching in Maryland Elementary Schools, With Limited Comparisons to Practices Revealed in a Nation-Wide Study." Unpublished doctoral dissertation, University of Maryland, College Park. 1965.

31. Drenchko, Elizabeth K. "The Comparative Effectiveness of Two Methods of Teaching Grade School Science." Report Number CRP-S-351 and Report Number BP-5-8054, Rutgers University, New Brunswick, New Jersey. 1966.
ED 018 429 MF $0.50 HC $4.85 95 p.

32. Dyrli, Odvard E. "An Investigation Into the Development of Combinatorial Mechanisms Characteristic of Formal Reasoning, Through Experimental Problem Situations With Sixth-Grade Students." Unpublished doctoral dissertation, Indiana University, Bloomington. 1967.
ED 021 722 MF $0.75 HC $7.10 140 p.

33. Eaton, Edward J. "An Examination of the Development of Science Concentrations For the Prospective Elementary School Teachers at the University of Texas." Journal of Research in Science Teaching 4: 154-158; September 1966.

34. Eccles, Priscilla J. "Teacher Behavior and Knowledge of Subject Matter in Sixth Grade Science." Journal of Research in Science Teaching 3: 345; December 1965.

35. Edwards, Thomas F. "A Study in Teaching Selected Intellectual Skills to Kindergarten Children." Unpublished doctoral dissertation, Michigan State University, East Lansing. 1966.
ED 025 415 MF $1.00 HC $12.10 240 p.

36. Engelmann, Siegfried, and James J. Gallagher. "Study of How a Child Learns Concepts About Characteristics of Liquid Materials." (Final Report). U. S. Office of Education Research Report, Contract 5-10-352. November 1966.
ED 014 428 MF $0.50 HC $3.40 66 p.

37. Finkelstein, Leonard B. "The Development of a 'Reading Free' Testing Procedure for the Evaluation of Knowledge and Understandings in Elementary School Science." Unpublished doctoral dissertation, Temple University, Philadelphia. 1967.
ED 024 563 MF $0.75 HC $9.50 188 p.

38. Floyd, Thomas W. "An Analysis of the Knowledge of Science of Pupils Prior to Instruction in the Seventh Grade." Unpublished doctoral dissertation, University of Illinois, Urbana. 1965.
ED 013 207 MF $0.75 HC $6.80 134 p.

39. Fryback, William H. "Evaluation of Multi-Level Reading Materials, Intraclass Discussion Techniques and Student Experimentations on Achievement in Fifth Grade Elementary Science." Unpublished doctoral dissertation, Oregon State University, Corvallis. 1965.

40. Gehrman, Joseph L. "A Study of the Impact of Authoritative Communication of Expected Achievement Upon Actual Achievement in Elementary School Science." Unpublished doctoral dissertation, The University of Illinois, Urbana. 1965.

41. Gerne, Timothy A. "A Comparative Study of Two Types of Science Teaching on the Competence of Sixth-Grade Students to Understand Selected Topics in Electricity and Magnetism." Unpublished doctoral dissertation, New York University. 1967.
ED 023 581 MF $0.75 HC $8.50 168 p.

42. Glaser, Robert. Adapting the Elementary School Curriculum to Individual Performance. Learning Research and Development Center, University of Pittsburgh. 1967.

43. Glaser, Robert, And Others. "Studies of the Use of Programmed Instruction in the Classroom." University of Pittsburgh Learning R and D Center. 1966.
ED 010 208 MF $0.75 HC $9.80 187 p.

44. Gleason, Walter P. "An Examination of Some Effects of Pupil Self-Instruction Methods Compared With the Effects of Teacher-Led Classes in Elementary Science on Fifth Grade Pupils." Unpublished doctoral dissertation, Boston University School of Education. 1965.

45. Griffin, Raymond V. "An Analysis of Selected Science Concepts to Determine Industrial Arts Related Experiences Suitable For an Integrated Elementary Industrial Arts Program at the Intermediate Grade Levels." (Research Study No. 1), Unpublished doctoral dissertation, Colorado State College, Greeley. 1965.

46. Gunnels, Frances G. "A Study of the Development in Logical Judgments in Science of Successful and Unsuccessful Problem Solvers in Grades Four through Nine." Unpublished doctoral dissertation, University of Alabama, Tuscaloosa. 1967.
ED 026 249 MF $0.50 HC $6.05 119 p.

47. Haddad, Wadi D. "Relationship Between Mental Maturity and the Level of Understanding of Concepts of Relativity in Grades 4-8." Unpublished doctoral dissertation, The University of Wisconsin, Madison. 1968.
ED 028 058 MF $2.50 HC $36.11 722 p.

48. Hardin, Henry N. "An Analysis of Selected Aspects of the Science Preparation of Prospective Elementary Teachers at the University of Miami." Unpublished doctoral dissertation, University of Miami, Miami, Florida. 1965.

49. Harris, William and Verlin Lee. "Mental Age and Science Concepts-A Pilot Study." Journal of Research in Science Teaching 4: 275-281; December 1966.

50. Haugerud, Albert R. "The Development of a Conceptual Framework For the Construction of a Multi-Media Learning Laboratory and Its Utilization For Elementary School Science." Unpublished doctoral dissertation, University of Washington, Seattle. 1966.

51. Hedges, William D., and Mary A. MacDougall. "Teaching Fourth Grade Science by Means of Programmed Science Materials With Laboratory Experiences Phase III." Science Education 49: 348-358; October 1965.

52. Heldman, Lawrence J. "Planning Elementary School Science Facilities." Unpublished doctoral dissertation, Columbia University, New York. 1966.
ED 024 582 MF $1.00 HC $12.00 238 p.

53. Helgeson, Stanley L. "An Investigation into the Relationships Between Concepts of Force Attained and Maturity as Indicated by Grade Levels." Unpublished doctoral dissertation, The University of Wisconsin, Madison. 1967.

54. Hiack, Paul S. "Laboratory Experiments in College Physical Science for Prospective Elementary School Teachers." Unpublished doctoral dissertation, Columbia University, New York. 1966.

55. Hines, Sallylee H. "A Study of Certain Factors Which Affect the Opinions of Elementary School Teachers in the Teaching of Science." Unpublished doctoral dissertation, Oklahoma State University, Stillwater. 1966.
ED 024 583 MF $1.25 HC $16.70 332 p.

56. Hoffart, Ervin H. "The Role of High School Teachers in Disseminating New Elementary Science Curriculums, Final Report." Education Development Center, Newton, Massachusetts.
ED 020 134 MF $0.25 HC $1.75 33 p.

57. Jarvis, Oscar T. "Arithmetic and Science Time Allotment Practices in Intermediate Grades." School Science and Mathematics 66: 322-324; April 1966.

58. Johnson, Mervin L. "A Determination of Aerospace Principles Desirable For Inclusion in Fifth or Sixth Grade Science Programs." Unpublished doctoral dissertation, Colorado State College, Greeley. 1966.
ED 021 710 MF $1.00 HC $11.40 226 p.

59. Jones, Howard L. "The Development of a Test of Scientific Inquiry, Using the Tab Format, and an Analysis of its Relationship to Selected Student Behaviors and Abilities." Unpublished doctoral dissertation, University of Texas, Austin. 1966.
ED 013 212 MF $0.75 HC $7.70 152 p.

60. Kellogg, Maurice G. "The Effect of Laboratory-Discovery Methods and Demonstration-Discussion Methods Upon Elementary Science Methods Students' Abilities to Analyze and Interpret Graphs." Unpublished doctoral dissertation, Indiana University, Bloomington. 1966.

61. Kenyon, Raymond G. "A Nine Year Comparative Study of the Status of Conservation Education in Public Elementary Schools of New York State From 1955 to 1964." Unpublished doctoral dissertation, State University of New York at Buffalo. 1965.

62. Koelsche, Charles L. "Scientific Literacy as Related to the Media of Mass Communication." School Science and Mathematics 65: 719-725; November 1965.

63. Kriebs, Jean O. "The Effect of Videotaped Elementary School Science Classroom Demonstrations on Science Teaching Performance of Preservice Teachers." Unpublished doctoral dissertation, Temple University, Philadelphia. 1967.

64. Lane, Rodney A. "Determination of the Competence in the AAAS Elementary Science Curriculum of Elementary School Teachers in Two Florida Counties." Unpublished doctoral dissertation, The Florida State University, Tallahassee. 1966.
ED 023 592 MF $0.75 HC $8.05 159 p.

65. Lansdown, Brenda, and Thomas S. Dietz. "Free Versus Guided Experimentation." Science Education 49: 210-213; April 1965.

66. Leake, John B. "A Study of Attitudes of Elementary Teachers Toward Science." Unpublished doctoral dissertation, Oklahoma State University, Stillwater. 1966.

67. Lipson, Joseph I. Light Test - Comparison Between Elementary School Children and College Freshmen. Research and Development Center, University of Pittsburgh. 1967.

68. Ljostad, Rodney A. "Industrial Arts Activities in the Enrichment of Science Experiences for Elementary Schools (with) Part II: The Guide, Illustrations, by Betty E. Ljostad." Unpublished doctoral dissertation, New York University. 1965.

69. Lowery, Lawrence F. "Development of an Attitude Measuring Instrument For Science Education." School Science and Mathematics 66: 494-502; May 1966.

70. Lowery, Lawrence F. "An Experimental Investigation into the Attitude of Fifth Grade Students Toward Science." School Science and Mathematics 67: 569-573; June 1967.

71. Lown, Donald E. "A Study of Factors Related to the Use of a Pan Balance by Fifth Grade Students." Unpublished Masters Thesis, The Ohio State University. 1967.

72. McBride, Richard E. "The Effect of an In-Service Science Training Program For Teachers on the Achievement of Elementary School Children." Unpublished doctoral dissertation, Cornell University, Ithaca, New York.

73. Menefee, Robert W. "Measuring Elementary School Children's Ability to Use Evidence From Scientific Instruments in Decision-Making Situations." Unpublished doctoral dissertation, The Ohio State University, Columbus. 1965.
ED 013 213 MF $0.75 HC $6.70 132 p.

74. Moorehead, William D. "The Status of Elementary School Science and How it is Taught." Unpublished doctoral dissertation, The University of Oklahoma, Norman. 1965.

75. Nasca, Donald. "Effect of Varied Presentations of Laboratory Exercises Within Programmed Materials on Specific Intellectual Factors of Science Problem Solving Behavior." Science Education 50: 437-457; December 1966.

76. Newport, John F. "An Evaluation of Selected Series of Elementary School Science Textbooks." Unpublished doctoral dissertation, University of Miami, Miami, Florida. 1965.

77. Novak, Joseph D. Development and Use of Audio-Tape Programmed Instruction For Elementary Science. Purdue University, Lafayette, Indiana. 1967.

78. O'Toole, Raymond J. "A Study to Determine Whether Fifth Grade Children Can Learn Certain Selected Problem Solving Abilities Through Individualized Instruction (Research Study Number 1)." Unpublished doctoral dissertation, Colorado State College, Greeley. 1966.
ED 021 714 MF $0.75 HC $8.40 166 p.

79. Ottley, LeRoy. "Readability of Science Textbooks For Grades Four, Five and Six." School Science and Mathematics 65: 363-366; April 1965.

80. Perrodin, Alex F. "Children's Attitudes Towards Elementary School Science." Science Education 50: 214-218; April 1966.

81. Perrodin, Alex F. "Children's Interests in Elementary School Science." School Science and Mathematics 65: 259-258; March 1965.

82. Pershern, Frank R. "The Effect of Industrial Arts Activities on Science Achievement and Pupil Attitudes in the Upper Elementary Grades." Unpublished doctoral dissertation, Texas A & M University, College Station. 1967.
ED 027 187 MF $0.75 HC $9.20 182 p.

83. Phillips, Darrell G. "An Investigation of Possible Hierarchical Dependency of Four Piaget-Type Tasks Under Two Methods of Presentation to Third-, Fifth-, and Seventh-Grade Children." Unpublished doctoral dissertation, The Florida State University, Tallahassee. 1967.
ED 022 667 MF $0.50 HC $3.25 63 p.

84. Price, Thomas D. "Elementary School Science: A Design For Subject Matter Selection and Organization." Unpublished doctoral dissertation, Stanford University, Stanford, California. 1966.
ED 024 587 MF $0.75 HC $8.25 163 p.

85. Quilling, Mary, And Others. "Research and Development Activities in R and I Units of Two Elementary Schools of Milwaukee, Wisconsin, 1966-1967." U. S. Office of Education Research Report, Contract 5-10-154, March 1968.
ED 020 911 MF $0.25 HC $1.25 23 p.

86. Raina, T. N. "How Well do Prospective Teachers Know General Science?" Science Education 51: 234-239; April 1967.

87. Raun, Chester E. "The Interaction Between Curriculum Variables and Selected Classroom Student Characteristics." Unpublished doctoral dissertation, The University of Texas, Austin. 1967.
ED 022 668 MF $0.50 HC $6.05 119 p.

88. Reese, Willard F. "A Comparison of Interest Level and Problem Solving Accuracy Generated by Single Concept Inductive and Deductive Science Films (Research Study Number 1)." Unpublished doctoral dissertation, Colorado State College, Greeley. 1966.
ED 026 250 MF $0.75 HC $8.55 169 p.

89. Rowe, Mary B., and Paul D. Hurd. "The Use of Inservice Programs to Diagnose Sources of Resistance to Innovation." Journal of Research in Science Teaching 4: 3-15; March 1966.
ED 010 990 MF $0.25 HC $0.95 17 p.

90. Rowland, George W. "A Study of the Relationship Between Socio-Economic Status and Elementary School Science Achievement." Unpublished doctoral dissertation, University of Missouri, Columbia. 1965.

91. Salstrom, David. "A Comparison of Conceptualization in Two Types of Guided Discovery Science Lesson." Unpublished doctoral dissertation, Kent State University, Kent, Ohio. 1966.

92. Sands, Theodore, and Charles R. Hicklin. The Development and Testing of Instructional Materials For Gifted Primary Pupils. Illinois State University, Normal. 1965.
ED 010 766 MF $0.50 HC $3.55 69 p.

93. Sands, Theodore, And Others. Concept Development Materials For Gifted Elementary Pupils - Final Report of Field Testing. Illinois State University, Normal. 1966.
ED 010 998 MF $0.25 HC $2.60 50 p.

94. Schulz, Richard W. "The Role of Cognitive Organizers in the Facilitation of Concept Learning in Elementary School Science." Unpublished doctoral dissertation, Purdue University, Lafayette. 1966.
ED 026 251 MF $1.00 HC $10.10 200 p.

95. Scott, Harry V. "Cognitive Analysis of a Curriculum: An Application of Taxonomy of Educational Objectives: Handbook I; Cognitive Domain to Science - A Process Approach." Unpublished doctoral dissertation, Columbia University, New York. 1966.
ED 024 588 MF $0.75 HC $8.30 164 p.

96. Scott, Norval C., Jr. "The Strategy of Inquiry and Styles of Categorization." Journal of Research in Science Teaching 4: 143-148; September 1966.

97. Senter, Donald R. "An Appraisal of an Elementary School Science Program." Unpublished doctoral dissertation, Wayne State University, Detroit. 1966.

98. Shadoin, Bernard. "Adapting Technical Scientific Data For Use in Elementary School, Earth Science." (Parts I and II), Unpublished doctoral dissertation, University of Arkansas, Fayetteville. 1966.

99. Skinner, Ray, Jr. "An Experimental Study of the Effects of Different Combinations of Television Presentations and Classroom Teacher Follow-Up on the Achievement and Interest of Fifth Graders." Unpublished doctoral dissertation, Kent State University, Kent, Ohio. 1966.

100. Smith, Billy A. "An Experimental Comparison of Two Techniques (Planetarium Lecture-Demonstration and Classroom Lecture-Demonstration) of Teaching Selected Astronomical Concepts to Sixth-Grade Students." Unpublished doctoral dissertation, Arizona State University, Tucson. 1966.

101. Smith, Doyne M., and Bernice Cooper. "A Study of the Use of Various Techniques in Teaching Science in the Elementary School." <u>School Science and Mathematics</u> 67: 559-566; June 1967.

102. Smith, Gary R. "Probability Estimates of the Capacities of Intermediate Pupils to Understand Selected Physical Science Generalizations." (Final Report), EDRS, National Cash Register Company, Rockville, Maryland, August 1967.
ED 014 432 MF $1.75 HC $23.55 469 p.

103. Snoble, Joseph J. "Status and Trends of Elementary School Science in Iowa Public Schools, 1963-1966." Unpublished doctoral dissertation, The University of Iowa, Iowa City. 1967.
ED 021 717 MF $1.25 HC $15.65 311 p.

104. Soy, Eloise M. "Attitudes of Prospective Elementary Teachers Toward Science as a Field of Specialty." <u>School Science and Mathematics</u> 67: 507-511; June 1967.

105. Stauss, Nyles G. "An Investigation Into the Relationship Between Concept Attainment and Level of Maturity." Unpublished doctoral dissertation, The University of Wisconsin, Madison. 1967.
ED 020 912 MF $0.50 HC $3.95 77 p.

106. Swan, Malcom D. "An Exploratory Study of Science Achievement As It Relates to Science Curricula and Programs at the Sixth-Grade Level in Montana Public Schools." Unpublished doctoral dissertation, University of Montana, Missoula. 1965.

107. Tating, Marcela T. "Priming Creative Thinking in Elementary School Science." Unpublished doctoral dissertation, The University of California, Los Angeles. 1965.

108. Taylor, Alton L. "Teacher Attitudes, Pupil Behavior, and Content Attributes in Relation to the Use of Programmed Science Materials at the Fourth Grade Level." Unpublished doctoral dissertation, The University of Virginia, Charlottesville. 1965.

109. Thier, Herbert D. "A Look at a First Grader's Understanding of Matter." Journal of Research in Science Teaching 3: 84-89; March 1965.

110. Thomas, Charles S. "A Comparison of a Uni-Phylum Approach to Zoology Via the Arthropoda With A Traditional Phylogenetic Program For the Preparation of Prospective Elementary School Teachers." Unpublished doctoral dissertation, Cornell University, Ithaca, New York. 1965.

111. Trout, Verdine E. "A Study of the Scope, Sequence, and Objectives of Elementary School Science as Revealed by State Science Guides." Unpublished doctoral dissertation, Oklahoma State University, Stillwater. 1966.
ED 023 594 MF $0.75 HC $6.55 129 p.

112. Uselton, Horace W. "Factors Related to Competence in Science of Prospective Elementary Teachers." Unpublished doctoral dissertation, University of Georgia, Athens. 1962.

113. Vinci, Thomas G. "An Analysis of Elementary Science Handbooks and Their Relation to Science Programs in Three Districts in New York City." Unpublished doctoral dissertation, Columbia University, New York. 1966.

114. Voelker, Alan M. "The Relative Effectiveness of Two Methods of Instruction in Teaching The Classificational Concepts of Physical and Chemical Change to Elementary School Children." Unpublished doctoral dissertation, The University of Wisconsin, Madison. 1967.

115. Weichinger, Theodore, Jr. "The Determination of Suitable Laboratory Experiences for a Physical Science Course for Prospective Elementary School Teachers." Unpublished doctoral dissertation, Colorado State College, Greeley. 1967.
ED 020 899 MF $1.25 HC $13.65 271 p.

116. Weigand, James E. "The Relative Merits of Two Methodologies For Teaching the Analysis of Children's Questions in Elementary School Science." Unpublished doctoral dissertation, Indiana University, Bloomington. 1967.

117. Wilson, John H. "Differences Between the Inquiry-Discovery and the Traditional Approaches to Teaching Science in Elementary Schools." Unpublished doctoral dissertation, The University of Oklahoma, Norman. 1967.
ED 021 721 MF $0.50 HC $5.15 101 p.

118. Wisconsin State Department of Public Instruction. The Status of Science and Mathematics in Wisconsin Public Schools. Wisconsin State Department of Public Instruction, Madison. 1966.

119. Ziegler, Robert E. "The Relative Effectiveness of the Use of Static and Dynamic Mechanical Models in Teaching Elementary School Children the Theoretical Concept - The Particle Nature of Matter." Unpublished doctoral dissertation, The University of Wisconsin, Madison. 1967.
ED 022 670 MF $0.75 HC $7.35 145 p.

120. Zeitler, William R. "The Effectiveness of Cooperative Planning Upon Children's Achievement in Science." Unpublished doctoral dissertation, The Ohio State University, Columbus. 1965.